Primary Care, Social Inequalities, and All-Cause, Heart Disease, and Cancer Mortality in US Counties, 1990

Leiyu Shi, DrPH, MBA, James Macinko, PhD, Barbara Starfield, MD, MPH, Robert Politzer, ScD, John Wulu, PhD, and Jiahong Xu, MPH

Objectives. We tested the association between the availability of primary care and income inequality on several categories of mortality in US counties.

Methods. We used cross-sectional analysis of data from counties (n = 3081) in 1990, including analysis of variance and multivariate ordinary least squares regression. Independent variables included primary care resources, income inequality, and sociodemographics.

Results. Counties with higher availability of primary care resources experienced between 2% and 3% lower mortality than counties with less primary care. Counties with high income inequality experienced between 11% and 13% higher mortality than counties with less inequality.

Conclusions. Primary care resources may partially moderate the effects of income inequality on health outcomes at the county level. (*Am J Public Health.* 2005;95:674–680. doi:10.2105/AJPH.2003.031716)

There is strong theoretical and empirical evidence for the association between strong national primary care systems and improved health indicators.[1–4] US ecological studies have demonstrated an association between the primary care physician-to-population ratio and various health outcomes. Better health outcomes were found in states with higher primary care physician-to-population ratios after sociodemographic measures (elderly populations, urban residents, minority populations, education, income, unemployment, pollution) and lifestyle factors (seatbelt usage, obesity, and smoking) were controlled for.[5] Geographic areas with more family and general physicians had lower hospitalization rates for conditions preventable with good primary care.[6] Individual-level and state-level measures of primary care resources were also significantly associated with lower heart disease and cancer mortality rates.[7–11]

Although many of the previous studies controlled for both environmental and individual-level determinants of health, a new appreciation of the role of contextual-level determinants of population health emerged during the past decade. In particular, there is an ongoing debate over the role of the distribution of income as a determinant of population health, with evidence both supporting and refuting what has become known as the *relative income hypothesis*—the proposition that the greater the gap in income between the rich and the poor in a given area, the worse the health status for the overall population of that area.[12–15] Although international and cross-country studies of the relative income hypothesis have resulted in conflicting conclusions,[16–18] there is considerable evidence that, at least within the United States, income inequality is associated with poorer population health.[19–21]

The pathways through which income inequality might affect health are still unknown, and hypotheses include psychosocial and material pathways.[12,19] In this study, we use income inequality as a proxy for social inequalities regardless of their cause. We include the measure of unequal income distribution as a measure of underlying social inequalities in order to test whether primary care resources might be one strategy to help remedy the poorer-than-expected health profile seen in communities that suffer from income and other social inequalities.

Our previous studies suggested that the availability of primary care partially attenuates the adverse effects of other community-level risk factors for poorer health, such as income inequality. Shi and colleagues[22] found that the supply of primary care services had an independent and positive impact on health indicators, and that in multivariate models when demographic, income, and health system covariates were controlled for, a higher supply of primary care services actually reduced the magnitude of the deleterious impact of income inequality on health outcomes. Using a multilevel model that included individual, community, and state-level variables, Shi and Starfield[23] found that even when they controlled for all covariates, an increase of 1 primary care physician per 10 000 population was associated with a 2% increase in the odds of reporting excellent/good health.

Although previous studies have examined the relation between income inequality, primary care, and health outcomes, questions remain about the level of aggregation in which contextual effects occur. This study tests the extent to which these effects are present at a smaller level of analysis: US counties. We chose counties because they represent distinct political and geographic units, are an important unit of local decisionmaking, and are used by health and social services organizations to plan and provide many (but not all) public health and other social programs.

METHODS

Data and Measures

We tested the effects of local-level primary care and social inequalities on a variety of health outcomes at the county level. The first outcome measure was total (all-cause) mortality, one of the most commonly used health status indicators.[24,25] The second outcome measure was mortality from heart disease, one of the principal causes of death in the United States and amenable to prevention and control by primary care.[26,27] Heart disease and its risk factors have also been associated with income and other social inequalities.[28,29] The third outcome measure was mortality from cancers. Although cancer mortality depends on access to specialty services and treatments, primary care has a

clear role in the prevention and early detection of some cancers, in the integration and coordination of care given during treatment and follow-up, and in the treatment of other comorbidities.[30]

All the mortality data were drawn from the Centers for Disease Control and Prevention compressed mortality files. We used data from 1990, the most recent period for which the complete set of other county-level variables was available. The Centers for Disease Control and Prevention WONDER/PC software[31] was used to directly standardize data for age and gender to the 1980 US population. Standardized mortality rates for each county are expressed as the number of deaths per 100 000 population.

For the purpose of this study, *primary care physicians* refers to doctors of medicine per 10 000 civilian population in active office-based patient care in family medicine, internal medicine, and pediatrics.[32] This variable is called *primary care* throughout this article. Counties were classified as to whether they fell below or above the national 75th percentile in terms of primary care physicians per 10 000 population. Physician data were obtained from the American Medical Association's annual publication *Physician Characteristics and Distribution in the US*.[33] Data were drawn from 1990.

Income distribution was measured by the Gini coefficient, wherein higher values indicate greater inequality in income distribution.[34,35] Household income data used to calculate county-level income inequality came from the US Census Bureau. The Gini coefficient was calculated using software developed by E. Welniak (unpublished software, US Census Bureau, 1988). Because of evidence of a skewed distribution of Gini data, we analyzed income inequality by grouping counties into Gini quartiles, that is, each county was assigned to 1 of 4 groups based on whether its level of income inequality (Gini) was below the national 25th, between the 25th and 50th, between the 50th and 75th, or above the 75th percentile. The group with the lowest levels of income inequality (the under-25th-percentile group) was used as the reference group in analyses. This technique has been employed in other studies.[20,36,37]

Additional sociodemographic variables known to be associated with population health were included in the analyses as covariates. Because of problems of intercorrelation, each of these variables (except education) was analyzed as a series of categorical variables in order to avoid problems of multicollinearity in multivariate analyses. The proportion of each county's population aged 25 years and above with at least a high school education *(percentage high school education)* was analyzed as a continuous variable. Counties were categorized as either above or below the national median for the proportion of their working population currently unemployed *(percentage unemployed)*, and the percentage of their population identified as Black or African American *(percentage Black)*. Previous studies have shown that there is an important relation between the percentage of African Americans in a given geographic area and other social inequalities.[38,39] Counties were also categorized into high (at or above the 75th percentile) or low (below the 75th percentile) for average household income (*average income*). These data came from the US Census Bureau.

Design

This study was an unmixed ecological analysis. The unit of analysis was each US county, as defined by the 1990 census. Because of missing or incomplete data, not all counties were included. The effective sample size was 3075 counties instead of the US total of 3081. Despite missing values, this sample represents 99.9% of all US counties. This analysis used only county-level ecological variables. In order to avoid an ecological fallacy, we make no inferences about individuals based on the results of these analyses.[40,41]

Analysis

In analyzing the data, we first tested the bivariate association between health outcomes and primary care, income inequality, and sociodemographic covariates. Because the independent variables were primarily expressed categorical variables, bivariate analyses were performed using 1-way analysis of variance. Scheffe multiple comparison tests were used in order to compare the differences among the 4 categories of income inequality.[42] We employed ordinary least squares regression for multivariate analyses because all dependent variables were continuous with independent and identically distributed errors.[42] A set of nested models was designed to examine the extent to which primary care and other covariates moderated the adverse effect of income inequality on mortality. In model 1, only income inequality was used as a predictor of mortality. Model 2 examined the same relation while adjusting for both primary care and the sociodemographic characteristics of the county. Regression coefficients and standard errors are presented along with tests of significance. We compared nested models (model 2 vs model 1) by calculating a delta sum of squares (F) test. This allowed us to determine whether adding the additional covariates in model 2 improved on model 1.[43]

RESULTS

Table 1 shows the means and standard deviations for the outcome and control variables used in this study. In 1990, mean all-cause mortality was 1011 per 100 000 and varied across counties from a low of about 132 to a high of 2176 that was almost twice the national average. Heart disease mortality represented, on average, nearly 45% of all-cause mortality, ranging from a low of 0 to a high of 1108 per 100 000. Cancer mortality accounted for approximately 22% of all mortality, ranging from 0 to about 567 per 100 000.

The mean county-level Gini coefficient was 0.42, with a range from 0.29 to 0.56. Twenty-six percent of counties were classified as high (above the 75th percentile) income inequality counties, whereas only 20% were classified as below the 25th percentile. Primary care physicians per 10 000 population ranged from a low of 0 to a high of approximately 40. The average value was nearly 5 physicians per 10 000 population.

Other covariates showed wide variation among counties. The percentage of the population in each county classified as Black or African American averaged almost 9%, ranging from 0% to 86%. The proportion of the active population currently unemployed averaged 6% and ranged from a low of 0% to a high of 36%. Household income ranged from

TABLE 1—Characteristics of Outcomes and Frequency Distribution of Covariates: US Counties, 1990[a]

	n (total)[b]	Percentage in Each Category	Mean (SD)	Range (Low-High)
All-cause mortality per 100 000 population	3081	100.00	1011.49 (262.39)	131.78–2176.47
Heart disease mortality per 100 000 population	3081	100.00	458.91 (147.86)	0.00–1107.69
Cancer mortality per 100 000 population	3081	100.00	222.54 (60.57)	0.00–566.67
Gini	3075	100.00	0.42 (0.04)	0.29–0.56
>75th percentile	808	26.28	…	…
50th–75th percentile	922	29.98	…	…
25th–50th percentile	727	23.64	…	…
≤25th percentile	618	20.10	…	…
Primary care physicians per 10 000 population	3076	100.00	4.96 (3.24)	0.00–39.53
<75th percentile	2307	75.00	…	…
≥75th percentile	769	25.00	…	…
Percent Black	3076	100.00	8.56 (14.33)	0.00–86.20
≥Median	1531	49.77	…	…
<Median	1545	50.23	…	…
Percent unemployed	3076	100.00	6.20 (2.78)	0.00–36.10
≥Median	1520	49.41	…	…
<Median	1556	50.59	…	…
Average income (in US $)	3076	100.00	15 209 (3518)	5559–38 794
<75th percentile	2305	74.93	…	…
≥75th percentile	771	25.07	…	…
Percentage of population with high school education	3076	100.00	69.56 (10.34)	31.60–95.50

[a]The mean and standard deviation are provided for continuous variables; the frequency and percentage are provided for categorical variables.
[b]Because of missing values, the total sample size may not reach the maximum of 3081.

$5559 to almost $39 000 with a mean value of $15 209. The county average for adults having completed high school was nearly 70% but ranged from 32% to 96%.

Table 2 shows the bivariate relations between each of the covariates and the health outcomes as reported from a 1-way analysis of variance. Figures reported in the first column under each outcome represent the average value of the outcome in counties within each category.

The Gini coefficient of income inequality showed a positive relation with health outcomes. Counties with higher levels of inequality were associated with higher levels of mortality. Counties in the lowest quartile (that is, those with the least inequality in household income) had, on average, statistically significantly ($P<.05$) lower all-cause, heart disease, and cancer mortality than those counties with higher income inequalities. Primary care showed the opposite effect. Counties in the highest primary care category (≥75th percentile) had significantly lower all-cause, heart disease, and cancer mortality than those counties with fewer primary care resources.

Counties with higher than the national median levels of African Americans, unemployed people, or those lacking a high school education had, on average, higher levels of all-cause, heart disease, and cancer mortality. Those counties with average household income above the 75th percentile had lower average rates of mortality from all causes, heart disease, and cancer.

Table 3 shows the results of multivariate ordinary least squares regressions that test the association of income inequality and primary care on health outcomes, while holding other health determinants constant. In the first column (all-cause mortality), model 1 shows that each category of increased income inequality was associated with higher average levels of mortality than the reference group. A similar pattern is present in model 2, although the magnitude of the association was lower for all categories than in model 1. In model 2, the highest magnitude of association occurred in the middle category (50th to 75th percentiles). When all other variables were held constant, counties in this quartile had about 12% higher mortality than those in the lowest quartile.

Primary care was significantly associated with lower all-cause mortality. Counties in the lowest 3 quartiles of primary care had approximately 2% higher mortality than those in the reference category.

Other covariates associated with higher mortality included a higher-than-median percentage of the population that was African American and higher-than-median levels of unemployment. The percentage of population with a high school education was negatively associated with mortality. Each 1% increase in the population completing high school was associated with about a 0.6% decrease in mortality rates. Average income was not statistically significantly associated with mortality in this model.

The second column in Table 3 examines the relation among mortality from heart disease and income inequality, primary care, and other covariates. The pattern is consistent with that observed with all-cause mortality. In model 1, each category of increased income inequality was associated with higher levels of mortality from heart disease. In model 2, the magnitude of this association was somewhat reduced but still significant. Counties in the middle Gini quartile had approximately 11% higher rates of heart disease mortality than those in the reference group. Other covariates associated with increased heart disease mortality include a higher-than-median proportion of African American population and higher-than-median levels of unemployment.

Primary care and education were associated with lower rates of heart disease mortality. Those counties with low levels of primary care (the lowest 75%) had, on average, 3% higher mortality than those counties with more primary care resources. Each 1% increase in the percentage of the population having completed high school was associated with a little less than a 0.7% decrease in mortality from heart disease. The effect of

TABLE 2—Analysis of Variance Results by Outcome Measure: US Counties, 1990 (n = 3075)

Predictor[a]	All-Cause Mortality per 100 000 Population		Heart Disease Mortality per 100 000 Population		Cancer Mortality per 100 000 Population	
	Mean	SD	Mean	SD	Mean	SD
Gini						
>75th percentile	1084.60****	263.59	491.19****	152.83	228.86****	61.78
50th–75th percentile	1057.39****	238.53	479.5****	135.58	234.04****	56.38
25th–50th percentile	1003.67****	249.29	459.99****	145.92	224.63****	57.93
≤25th percentile	856.24****	244.44	384.76****	135.67	194.59****	59.66
Primary Care						
<75th percentile	1030.90****	262.53	471.37****	148.85	225.51****	61.11
≥75th percentile	953.25****	253.35	421.53****	138.37	213.63****	58.08
Percent Black						
≥Median	1030.91****	277.79	471.26****	161.02	226.75****	66.87
<Median	992.24****	244.76	446.67****	132.47	218.37****	53.30
Percent unemployed						
≥Median	1037.62****	223.00	470.85****	128.94	227.58****	55.19
<Median	984.74****	295.05	446.68****	164.14	217.39****	65.25
Average income						
<75th percentile	1040.37****	246.05	475.19****	140.77	226.02****	57.21
≥75th percentile	925.15****	289.54	410.24****	157.64	212.14****	68.66
Percent high school education						
≥Median	936.40****	269.73	421.45****	150.37	212.14****	62.23
<Median	1087.07****	231.45	496.61****	135.23	233.01****	57.00

[a]One-way analysis of variance was performed to find the overall difference among 4 groups for Gini. The Scheffe multiple comparison procedure was used to further compare paired differences between each of the 4 groups after rejection of the overall hypothesis that at least 1 group is different from the others. The results from Scheffe comparison procedure indicate that each mortality outcome for Gini ≤25th percentile group was significantly lower than that of the other Gini groups ($P < .05$). *T*-tests were used to compare variables with only 2 groups.
*$P < .05$; **$P < .01$; ***$P < .001$; ****$P < .0001$.

average household income was not statistically significant.

The third column of Table 3 presents results for cancer mortality. Model 1 shows that income inequality was associated with higher cancer mortality, a relation that was somewhat reduced in magnitude in model 2. When other health determinants were controlled for, counties in the middle Gini category experienced about 13% increased mortality over those in the reference category.

Higher primary care was associated with lower cancer mortality. Counties in the lowest primary care quartiles had about 2% higher cancer mortality than those in the reference group. Counties with a higher-than-median proportion of African Americans also experienced higher levels of cancer mortality. Each 1% increase in the percentage of the population having completed high school was associated with a less than 0.5% decrease in cancer mortality. Unemployment and average household income had no statistically significant effect.

DISCUSSION

This study shows that in US counties, greater primary care resources are consistently associated with lower rates of all-cause, heart disease, and cancer mortalities—even in the presence of income inequality and other health determinants. In multivariate regressions, counties with the lowest levels of primary care resources experienced 2% to 3% higher mortality than counties with higher levels of primary care resources. Income inequality was also found to be a significant predictor of county-level variation in mortality. Counties in higher-income inequality quartiles experienced 11% to 13% higher mortality than counties in the lowest quartile. These findings are consistent with that found in prior studies performed at the state and national levels.[11,44] Because this is an ecological study, it cannot show that the same individuals who suffer most from ill health because of income or other social inequalities would gain the most from improved availability of primary care. However, we believe that a plausible causal chain leads from income inequality to mortality. There is evidence that income inequality has negative effects on the psychosocial environment that can contribute to increased stress, poorer social relations, and reduced support at both the individual and population levels.[45–47] These conditions may lead to a higher prevalence of certain diseases[48] as well as risk factors (e.g., smoking, hypertension, and obesity) for heart disease and some cancers. Many of these risk factors have also been shown to be more prevalent in areas with higher social inequalities.[29,49] The alternative neomaterial explanation for the observed relation between income inequality and health is that poor individuals living in unequal areas suffer from worse living conditions and have poorer access to quality education, health, and other social services.[18,19] These material deprivations are thought to lead to more limited life chances and a poorer health profile.

There are several reasons why more county-level supply of primary care resources might be associated with better health outcomes. First, the effect of primary care resources may be partially because physicians trained in primary care are more likely to provide good quality primary care services than those who are not.[50,51] A system of good-quality primary care services may be able to ameliorate some of the ultimate consequences of social inequalities at the population level by contributing to reduced levels of disease transmission, lowering aggregate levels of risk factors (such as hypertension, smoking, weight gain), improving countywide screening and early diagnosis activities, and developing systems to coordinate care.[52,53] Exercise of these functions should contribute to improved functioning of the health system at large because strong primary care not only means more prevention but, ideally, can also

TABLE 3—Multivariate Relations of All-Cause, Cardiovascular Disease, and Cancer Mortality With Primary Care, Income Inequality, and Health Determinants: US Counties, 1990 (n = 3075)

	All-Cause Mortality		Heart Mortality		Cancer Mortality	
Predictors[a]	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	856.24 (10.02)****	1367.52 (49.61)****	384.76 (5.74)****	642.57 (28.52)****	194.59 (2.37)****	271.18 (12.13) ****
Gini						
> 75th percentile	228.36 (13.31)****	147.42 (15.14)****	106.43 (7.63)****	63.17 (8.71)****	34.27 (3.15)****	24.16 (3.70) ****
50th–75th percentile	201.15 (12.95)****	160.64 (13.14)****	94.74 (7.42)****	73.16 (7.55)****	39.45 (3.06)****	34.76 (3.21) ****
25th–50th percentile	147.43 (13.63)****	131.59 (13.10)****	75.24 (7.81)****	66.92 (7.53)****	30.04 (3.22)****	28.51 (3.20) ****
≤ 25th percentile	0.00	0.00	0.00	0.00	0.00	0.00
Primary care						
< 75th percentile	. . .	23.80 (10.76)*	. . .	19.96 (6.19)**	. . .	5.29 (2.63)*
≥ 75th percentile	. . .	0.00	. . .	0.00	. . .	0.00
Percent Black						
≥ Median	. . .	101.33 (9.06)****	. . .	53.87 (5.21)****	. . .	17.36 (2.21) ****
< Median	. . .	0.00	. . .	0.00	. . .	0.00
Percent unemployed						
≥ Median	. . .	29.91 (9.42)**	. . .	20.23 (5.42)***	. . .	0.53 (2.30)
< Median	. . .	0.00	. . .	0.00	. . .	0.00
Average income						
< 75th percentile	. . .	8.52 (11.38)	. . .	11.43 (6.54)	. . .	–4.36 (2.78)
≥ 75th percentile	. . .	0.00	. . .	0.00	. . .	0.00
Percentage high school education	. . .	–8.10 (0.59)****	. . .	–4.29 (0.34)****	. . .	–1.18 (0.14) ****
Adjusted R^2	0.100	0.195	0.068	0.163	0.056	0.097
Delta sum of squares test (F-statistic)	. . .	74.18***	. . .	70.48***	. . .	29.08***

[a]The coefficient for categorical variables is the difference between the reference group and the compared group, and the coefficient for continuous variables (e.g., percent high school education) is the slope, the magnitude of change of the outcome per 1 unit change in predictor. Values in parentheses represent standard deviations.
*P < .05; **P < .01; ***P < .001; ****P < .0001.

lead to more efficient referral, coordination, and continuity of care.[54,55]

Moreover, the recommendation that expansion of primary care resources might be one strategy to improve population health in areas with high levels of income inequality does necessarily depend on the mechanism linking such inequalities with poorer health. Improving primary care resources in counties with high levels of social inequalities should contribute to incremental improvements in both material conditions and better management of conditions and behaviors associated with increased psychosocial stress.

In terms of the effect of income inequality on health outcomes, prior studies also found that the largest independent income inequality effects occur at the county rather than the census tract level.[56] This finding is important because counties are often the local decision-making unit for issues affecting organization of local health, education, and other social services.[57] One difficulty posed by county-level analyses is the likelihood of random fluctuations in both numerators and denominators of mortality and other rates through small area geographic aggregation. The presence of low-population counties that did not experience heart or cancer mortalities in 1990 may have led to some imprecision in multivariate models. Moreover, using state-level aggregate data would also have had the advantage of attenuating the likely "crossover" effect encountered when smaller units of analysis are used for measuring the availability of medical care and mortality.[58] However, our results were broadly consistent with those in other studies that compensated for this potential limitation. McLaughlin and Stokes[38] used a 5-year average (centered on 1990) for all-cause mortality and also found that US counties with higher income inequality had higher mortality rates, even when they adjusted for average income and percentage African American. For this reason, we do not believe that using the county as a unit of analysis has significantly biased our findings.

As a final sensitivity test, results were analyzed for geographic trends within the major US regions as defined in by the Census Bureau (i.e., Northeast, South, Midwest, and West). For all outcomes, regional variables were found to be statistically significant although their inclusion in the model did not affect other covariates.

In interpreting the results of this study, several limitations require consideration. First, the finding of a relation between an increased number of primary care physicians and lower population mortality does not necessarily imply that the mere presence of more primary care physicians ensures either that more individuals in the population will be exposed

to primary care or that the delivery of primary care will produce better health outcomes at the individual level. Only studies performed at the individual level would test these hypotheses.

The coefficient of determination (R^2) values for the multivariate models were smaller in magnitude than values obtained from similar analyses performed at the state level. Although this is not necessarily a study limitation, it does indicate that several factors affecting the health of populations could not be modeled here because of a lack of county-level data. One difficulty in constructing more comprehensive models of health determinants is that many of these factors are collinear. In this study, average county income was not found to be a statistically significant predictor of mortality, although it was in other studies.[38] This discrepancy is likely to be the result of the strong correlation between average country income, education levels, and percentage African American. Each of these factors is interrelated and also correlated with income inequality.

A final potential limitation is that primary care physician availability is likely to be an inadequate proxy for the receipt of good primary care. Ultimately, we would like better information on the structural characteristics and practice features of primary care. Unfortunately, there are no data that make it possible to adequately characterize receipt of good primary care (as distinguished from receipt of ambulatory care services, which also include specialty care) at the state or county levels. Nonphysician providers of primary care were not captured in this study. For these reasons, it is likely that our analysis underestimates the overall contribution of primary care to improved population health. ■

About the Authors

Leiyu Shi is with the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health, Baltimore, Md. James Macinko is with the Steinhardt School of Education at New York University, New York, NY. Barbara Starfield is with the Johns Hopkins Bloomberg School of Public Health. Robert Politzer and John Wulu are with the Bureau for Primary Care, Health Resources and Services Administration, US Department of Health and Human Services, Bethesda, Md. Jiahong Xu is a doctoral student at the Johns Hopkins Bloomberg School of Public Health.

Requests for reprints should be sent to Leiyu Shi, Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, 624 N. Broadway, Room 406, Baltimore, MD 21205 (e-mail: lshi@jhsph.edu).

This article was accepted June 2, 2004.

Contributors

L. Shi originated the study and supervised all aspects of its implementation. J. Macinko led the writing. B. Starfield synthesized analyses and interpreted results. R. Politzer and J. Wulu assisted with the writing and analysis. J. Xu performed statistical analyses. All authors helped to conceptualize ideas and review drafts of the article.

Acknowledgments

This study was funded by the Bureau of Primary Health Care, Johns Hopkins Primary Care Policy Center.

Human Participant Protection

This study was approved as exempt by Johns Hopkins University institutional review board because no human participants were involved in this study.

References

1. Starfield B. *Primary Care: Balancing Health Needs, Services and Technology.* New York, NY: Oxford University Press; 1998.
2. Starfield B. Is primary care essential? *Lancet.* 1994; 344:1129–1133.
3. Starfield B, Shi L. Policy relevant determinants of health: an international perspective. *Health Policy.* 2002; 60(3):201–216.
4. Macinko J, Starfield B, Shi L. The contribution of primary care systems to health outcomes within OECD countries, 1970–1998. *Health Serv Res.* 2003;38: 819–853.
5. Farmer FL, Stokes CS, Fisher RH. Poverty, primary care and age-specific mortality. *J Rural Health.* 1991;7:153–169.
6. Parchman M, Culler S. Primary care physicians and avoidable hospitalization. *J Fam Pract.* 1994;39: 123–128.
7. Shi L. The relation between primary care and life chances. *J Health Care Poor Underserved.* 1992;3: 321–335.
8. Shi L. Primary care, specialty care, and life chances. *Int J Health Serv.* 1994;24:431–458.
9. Shi L. Balancing primary versus specialty care. *J R Soc Med.* 1995;88:428–432.
10. Kawachi I, Kennedy B. Income inequality and health: pathways and mechanisms. *Health Serv Res.* 1999;34:215–227.
11. Shi L, Starfield B, Politzer R, Regan J. Primary care, self-rated health, and reduction in social disparities in health. *Health Serv Res.* 2002;37:529–550.
12. Wilkinson R. Socioeconomic determinants of health: health inequalities: relative or absolute material standards? *BMJ.* 1997;314:591–595.
13. Lochner K, Pamuk E, Makuc D, Kennedy B, Kawachi I. State-level income inequality and individual mortality risk: a prospective, multilevel study. *Am J Public Health.* 2001;91:385–391.
14. Kennedy BP, Kawachi I, Glass R, Prothrow-Stith D. Income distribution, socioeconomic status, and self rated health in US: a multilevel analysis. *BMJ.* 1999; 317:917–921.
15. Mellor JM, Milyo J. Reexamining the evidence of an ecological association between income inequality and health. *J Health Polit Policy Law.* 2001;26: 487–522.
16. Gravelle H, Wildman J, Sutton M. Income, income inequality and health: what can we learn from aggregate data? *Soc Sci Med.* 2001;54:577–589.
17. Muller A. Education, income inequality, and mortality: a multiple regression analysis. *BMJ.* 2002; 325:1–4.
18. Lynch J, Davey Smith G, Hillemeier M, Shaw M, Raghunathan T, Kaplan G. Income inequality, the psychosocial environment, and health: comparisons of wealthy countries. *Lancet.* 2001;358:194–200.
19. Judge K, Paterson I. *Poverty, Income Inequality and Health.* Auckland, N Z: New Zealand Treasury; 2002.
20. Blakely T, Lochner K, Kawachi I. Metropolitan area income inequality and self-rated health–a multilevel study. *Soc Sci Med.* 2002;54:65–77.
21. Franks P, Fiscella K. Primary care physicians and specialists as personal physicians. Health care expenditures and mortality experience. *J Fam Pract.* 1998;47: 105–109.
22. Shi L, Starfield B, Kennedy B, Kawachi I. Income inequality, primary care, and health indicators. *J Fam Pract.* 1999;48:275–284.
23. Shi L, Starfield B. Primary care, income inequalities, and self-rated health in the United States: a mixed-level analysis. *Int J Health Serv.* 2000;30:541–555.
24. Bergner M. Measurement of health status. *Med Care.* 1985;23:696–704.
25. Kawachi I, Kennedy B, Wilkinson R, eds. *Income Inequality and Health.* New York, NY: The New Press; 1999. *The Society and Population Health Reader;* Vol 1.
26. Pharoah PD, Sanderson SP. Health promotion in primary care: modelling the impact of intervention on coronary heart disease and stroke. *J Public Health Med.* 1995;17(2):150–156.
27. Barnett HJ, Eliasziw M, Meldrum HE. Evidence based cardiology: prevention of ischaemic stroke. *BMJ.* 1999;318:1539–1543.
28. Kahn HS, Tatham LM, Pamuk ER, Heath CW Jr. Are geographic regions with high income inequality associated with risk of abdominal weight gain? *Soc Sci Med.* 1998;47:1–6.
29. Diez-Roux AV, Link BG, Northridge ME. A multilevel analysis of income inequality and cardiovascular disease risk factors. *Soc Sci Med.* 2000;50: 673–687.
30. Campbell RJ, Ramirez AM, Perez K, Roetzheim RG. Cervical cancer rates and the supply of primary care physicians in Florida. *Fam Med.* 2003;35(1):60–64.
31. Friede A, Reid JA, Ory HW. CDC WONDER: a comprehensive on-line public health information system of the Centers for Disease Control and Prevention. *Am J Public Health.* 1993;83:1289–1294.
32. National Center for Health Statistics. Health status indicators: definitions and national data. *Statistical Notes.* 1992;1:1–8.

33. American Medical Association. *Physician Characteristics and Distribution in the United States.* Chicago, Ill: AMA Press; 1991.

34. Coulter P. *Measuring Inequality: A Methodological Handbook.* Boulder, Colo: Westview Press; 1989.

35. Atkinson A. The economics of inequality. Oxford, England: Clarendon Press; 1983.

36. Kennedy B, Kawachi I, Glass R, Prothrow-Stith D. Income distribution, socioeconomic status, and self rated health in the United States: multilevel analysis. *BMJ.* 1998;317:917–921.

37. Kawachi I, Kennedy BP. The relationship of income inequality to mortality: does the choice of indicator matter? *Soc Sci Med.* 1997;45:1121–1127.

38. McLaughlin DK, Stokes CS. Income inequality and mortality in US counties: does minority racial concentration matter? *Am J Public Health.* 2002;92: 99–104.

39. Deaton A, Lubotsky D. Mortality, inequality and race in American cities and states. *Soc Sci Med.* 2003; 56:1139–1153.

40. Susser M. The logic in ecological, I: the logic of analysis. *Am J Public Health.* 1994;84:825–829.

41. Diez-Roux A. Bringing context back into epidemiology: variables and fallacies in multilevel analysis. *Am J Public Health.* 1998;88:216–222.

42. Fisher L, van Belle G. *Biostatistics: A Methodology for the Health Sciences.* New York, NY: John Wiley & Sons; 1993.

43. Tacq J. *Multivariate Analysis Techniques in Social Science Research.* Thousand Oaks, Calif: Sage Publications; 1997.

44. Shi L, Starfield B. The effect of primary care physician supply and income inequality on mortality among blacks and whites in US metropolitan areas. *Am J Public Health.* 2001;91:1246–1250.

45. Kawachi I, Kennedy B, Wilkinson R. Crime: social disorganization and relative deprivation. *Soc Sci Med.* 1999;48:719–731.

46. Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *Am J Public Health.* 1997;87:1491–1498.

47. Lomas J. Social capital and health: implications for public health and epidemiology. *Soc Sci Med.* 1998;47: 1181–1188.

48. Holtgrave DR, Crosby RA. Social capital, poverty, and income inequality as predictors of gonorrhoea, syphilis, chlamydia and AIDS case rates in the United States. *Sex Transm Infect.* 2003;79(1):62–64.

49. Kahn HS, Patel AV, Jacobs EJ, Calle EE, Kennedy BP, Kawachi I. Pathways between area-level income inequality and increased mortality in US men. *Ann N Y Acad Sci.* 1999;896:332–334.

50. Rosenblatt R, Hart L, Baldwin L, Chan L, Schneeweiss R. The generalist role of specialty physicians: is there a hidden system of primary care? *JAMA.* 1998;279:1364–1370.

51. Weiner JP, Starfield BH. Measurement of the primary care roles of office-based physicians. *Am J Public Health.* 1983;73:666–671.

52. Weinberger J. Stroke and TIA. Prevention and management of cerebrovascular events in primary care. *Geriatrics.* 2002;57(1):38–43.

53. Goldstein LB, Farmer A, Matchar DB. Primary care physician–reported secondary and tertiary stroke prevention practices. A comparison between the United States and the United Kingdom. *Stroke.* 1997;28: 746–751.

54. Casanova C, Colomer C, Starfield B. Pediatric hospitalization due to ambulatory care–sensitive conditions in Valencia (Spain). *Int J Qual Health Care.* 1996; 8(1):51–59.

55. Casanova C, Starfield B. Hospitalizations of children and access to primary care: a cross-national comparison. *Int J Health Serv.* 1995;25:283–294.

56. Soobader MJ, LeClere FB. Aggregation and the measurement of income inequality: effects on morbidity. *Soc Sci Med.* 1999;48:733–744.

57. Shi L, Regan J, Politzer RM, Luo J. Community health centers and racial/ethnic disparities in healthy life. *Int J Health Serv.* 2001;31:567–582.

58. Hadley J. *More Medical Care, Better Health?* Washington, DC: The Urban Institute Press; 1982.